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Carnegie Mellon University
Software Engineering Institute

1991 Summary of Technical Operations

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1991 Summary of Technical Operations



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Software Engineering Institute
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213

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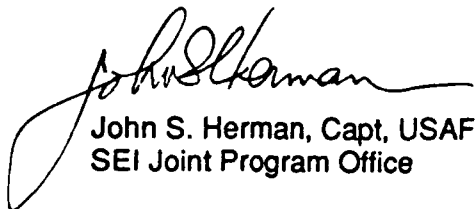
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The ideas and findings in this report should not be construed as an official DoD position. It is published in the interest of scientific and technical information exchange.

Review and Approval

This report has been reviewed and is approved for publication.

FOR THE COMMANDER



John S. Herman, Capt, USAF
SEI Joint Program Office

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Summary of Accomplishments

Members of the **Software Process Assessment (SPA) Project** conducted the second vendor assessment training class, which included 21 people from 5 vendor organizations.

The SPA project team developed an assessment tutorial: "Software Process Assessment: Impacts of the New Capability Maturity Model (CMM)." The tutorial was presented at the 1991 SEI Affiliates Symposium.

The **CMM Project** released two reports at the 1991 SEI Affiliates Symposium: *Capability Maturity Model for Software* (CMU/SEI-91-TR-24) and *Key Practices of the Capability Maturity Model* (CMU/SEI-91-TR-25).

Members of the **Software Process Definition Project** developed and delivered a software process definition workshop entitled "Defining the Software Process—Getting Started" in support of their process improvement efforts.

Members of the **Software Process Definition Project** participated in the development of the Software Technology for Adaptable, Reliable Systems (STARS) Process Operational Concept Document, which serves as the technical foundation for the process component of the STARS environment.

The NASA Program Office has officially decided to expand the use of **Rate Monotonic Analysis (RMA)**, which was originally isolated to the Data Management System, to the entire Space Station Program.

The **Rate Monotonic Analysis for Real-Time Systems (RMARTS) Project** continued to discover several examples of RMA adoption within the marketplace. At the TRI-Ada '91 Conference, promotion materials by Telesoft advertised "hard deadline scheduling, based on Rate Monotonic Scheduling as defined by the SEI;" an Ada training company (Absolute Software) has, for over a year, included rate monotonic scheduling concepts in two of their courses; and a Swedish company (Saab Space) has designed a microprocessor that supports rate monotonic analysis and rate monotonic scheduling algorithms, such as priority inheritance.

The **RMARTS and Real-Time Embedded Systems Testbed Projects** are cooperating in developing benchmarks necessary for the rate monotonic analysis of real-time software, as well as guidelines for the creation of such benchmarks.

The final version of **Serpent**, a user interface management system, was released. An announcement about the opportunity to license Serpent from CMU appeared in Commerce Business Daily in July.

Members of the **Software Architectures Engineering (SAE) Project** delivered a special report to Air Force Electronic Combat Office (AFECO): *Definition of Engineering Requirements for AFECO—Lessons from Flight Simulators*.

Together with a resident affiliate from Naval Coastal Systems Center (NCSC), SAE project members developed a four-day course for training NCSC developers in adapting and using the object-connection update structural model.

Regarding software configuration management support, the **Software Development Environments Project** investigated the state of commercial technology, which project members have captured through a spectrum of concepts and four observed paradigms.

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This section provides a summary of accomplishments for the year 1991

In conjunction with the Software Process Program, **Empirical Methods** project members designed the process maturity questionnaire prototype, which was presented at the 1991 SEI Affiliates Symposium.

In January, the **Risk Focus Area** held a government workshop for program executive officers and senior-level executives from the services and the Office of the Secretary of Defense.

Members of the **Risk Focus Area** successfully negotiated an agreement with their first strategic DoD partner, the Navy. Risk staff members also completed the first risk assessment, which included assessment team training, a quick look assessment, and a detailed analysis of two risk areas.

The **Graduate Curriculum Project** completed three new products (reports and educational materials packages) related to software engineering project courses, as well as a curriculum report, a directory of schools teaching software engineering, and an educational materials package on software inspections.

The 5th Annual SEI Conference on Software Engineering Education was held in Pittsburgh, followed by a one-day Educator Development Workshop. A Continuing Education Workshop was held in conjunction with the annual **SEI Affiliates Symposium**.

The CMU **Master of Software Engineering** program graduated its first six students in December 1991.

The Academic Series completed its eighth semester of production in the spring by videotaping updates of three courses: "Software Creation and Maintenance;" "Software Project Management;" and "Software Analysis." In the Fall, "Software Requirements Engineering" was added to the series.

The **Continuing Education Project** developed Software Quality Improvement, an executive seminar for the Continuing Education Series.

A new videotape, "Executive Leadership for Software," was added to the Technology Series. In this videotape, Watts Humphrey describes an improvement strategy based on the capability maturity model developed at the SEI.

The third annual **Computer Security Incident Response Workshop** was held in Washington, D.C., on August 6-8, 1991. The first draft of a computer security tutorial, focused on Internet-connected UNIX systems, was presented at the workshop.

During the fourth quarter, DARPA approved the expansion of the **Computer Emergency Response Team/Coordination Center (CERT/CC)**.

In 1991, 14 new educational organizations became affiliates and 36 new industry organizations signed affiliation agreements for information exchange and information dissemination.

The sixth annual **SEI Affiliates Symposium** was held in August and included more than 25 hours of presentations highlighting SEI programs, plans, and activities, particularly in the area of software process. More than 700 representatives from affiliate organizations attended the symposium.

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Software Process

The Software Process Focus Area objectives are to improve the process of software development. Project members within this Focus Area are assessing the actual practice of software engineering in the defense community, training organizations to gain management control over their software development processes, supporting the use of quantitative methods and measures as a basis for process improvement, and developing improved methods for software process management.

The Software Process Assessment (SPA) Project helps organizations improve their software development process by providing a structured framework for assessing their current practice. The objectives of an assessment are to determine the organization's software process maturity, identify key areas for improvement, and help the organization initiate those improvements.

●●●●●●●●●●●●●●●● Software Process Assessment

The SPA Project provides assessment briefings, training, and coaching services. In addition, it supports nine commercial assessment vendors. The project is currently focusing its efforts on assessments as components of comprehensive process improvement programs.

Early this year, project members conducted a second vendor assessment training class for 17 people from 9 vendor organizations. During the fourth quarter, an update workshop was held for all currently licensed vendors. Workshop attendees were provided training in the revised Capability Maturity Model (CMM). In addition to vendor training, project members conducted 2 software process assessment training classes for strategic clients.

During 1991, authorized SEI personnel observed vendor-assisted assessments by the Software Productivity Consortium, Contel, Pragma, Arthur D. Little, and American Management Systems. They also provided assessment coaching to a number of DoD and commercial clients including: Air Force Logistics Command, Army Materiel Command (AMC), 7th Communications Group of the Pentagon, Hewlett Packard, GTE Government Systems, Science Applications International, Motorola, Boeing Aerospace, and Harris Corporation.

The project team developed an assessment tutorial: "Software Process Assessment: Impacts of the New CMM." This tutorial was presented at the 1991 SEI Affiliates Symposium, in conjunction with a report on the state of software practice in the United States.

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**Software Capability
Evaluation**

The Software Capability Evaluation (SCE) Project helps Department of Defense (DoD) acquisition organizations evaluate the capability of contractors to competently develop and maintain software. The project is improving and implementing an evaluation method that examines the software process of contractors for use in software-intensive acquisitions.

This year, project members conducted 6 offerings of the SCE Team Training course at the SEI. SCE Team Training focuses on intensive case studies designed to train evaluation teams chosen to conduct SCE site visits at contractor facilities. Training was given to 170 representatives from 20 major DoD and commercial organizations, including several from the Army, Air Force, Navy, Office of the Secretary of Defense, Strategic Defense Initiative Organization, Defense Information Systems Agency, Jet Propulsion Laboratory (JPL), National Defense University, and Defense Systems Management College. This number represents a 200 percent increase over the number of people trained during 1990.

In May, the SCE Team Training course was also taught on-site at the Air Force Systems Command (AFSC), Electronic Systems Division (ESD) at Hanscom Air Force Base (AFB) in Boston. The course was attended by 17 people from 3 different AFSC product divisions: Aeronautical Systems Division, Space Systems Division, and ESD

The project sponsored an SCE experience panel during the 1991 SEI Affiliates Symposium. Participants delivered brief presentations describing their experiences in leading SCE teams during site visits. A question and answer session followed each presentation. The panel session proved to be an excellent forum for government, contractor, and SEI personnel to exchange information and feedback about the SCE method.

The project also completed work on an initial version of the Assistant for Evaluation of Software Practices (AESOP) tool, which is an automated tool designed to help evaluation teams conduct efficient site visits. Beta testing of AESOP was initiated at the Naval Command Control and Ocean Surveillance Center in San Diego.

Part A of the guide for implementing SCE in software-intensive acquisitions, entitled "Introducing SCE," was completed in draft form. Comments from selected SCE pilot partners are being solicited on this draft to ensure that end-user perspectives are built into the final document.

Project members supported ongoing DoD acquisitions in several other capacities. An issue paper, "Evaluations Versus Assessments and Other Issues," was delivered to the AMC personnel to answer many of the commonly-asked questions about the SCE method. The project assisted the Strategic Defense Initiative Organization and Standard Systems Center (SSC) at Gunter AFB by providing draft SCE language relevant to government acquisition documentation required to conduct a source selection.

An SCE site visit policy was created by the SEI. Project members observed six SCE site visits conducted by the government. These observations provided invaluable real-world data on the use of the SCE method and helped the project evolve the method. In addition to assisting the project in creating transition documents and

teaching the team training course, the government resident affiliate assigned to the project has conducted over six SCE site visits. Thus, user involvement and feedback in the method is fed directly into project activities.

Strategic relationships were initiated with two key service organizations, ESD and AMC. These partners were chosen as important leverage points for transitioning the SCE method from the SEI to the government. Additional strategic partners will be chosen in 1992.

This year, the project primarily supported ESD, providing assistance in implementing SCEs on two high-leverage acquisitions, one in source selection and the other in contract monitoring. In June, a project member briefed over a dozen Army Software Life-Cycle Support Center managers on the steps essential to successfully install the SCE method in an organization.

The Capability Maturity Model (CMM) Project began in April, 1991 as a spin-off of the Software Capability Evaluation Project. The CMM Project maintains a model describing how organizations can improve their software process maturity. This model will be continuously updated as the state of the practice evolves in software engineering, total quality management, and other relevant areas of improvement. The CMM will elaborate on software practices that provide clear strategies for improving the software process and increasing an organization's software capability.

The CMM Project released two reports at the 1991 Affiliates Symposium: *Capability Maturity Model for Software* (CMU/SEI-91-TR-24) and *Key Practices of the Capability Maturity Model* (CMU/SEI-91-TR-25). The first report describes the CMM and how it is used in process assessments and capability evaluations. The second report lists the key software management and engineering practices for each maturity level. It acts as a guide for software professionals wishing to improve the maturity of their organizations' software processes and serves as a reference for assessment and evaluation teams when conducting on-site investigations of an organization's software process. Both reports were developed with extensive industry and government interaction.

Presentations at the SEI Affiliates Symposium also addressed scoring issues and the project release strategy for broad-scale dissemination of CMM products. Using the key practices and questions from the preliminary version of the maturity questionnaire, a prototype of an updated maturity questionnaire containing questions for maturity level 2 was developed and distributed.

The Software Acquisition Process Development Project was renamed the Software Acquisition Evaluation Methods (SAEM) Project to more accurately reflect the direction of the project. The objective of the SAEM Project was to develop methods that assist acquisition agents in evaluating the software component of a system at various phases in the acquisition process.

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**Capability Maturity
Model**

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**Software Acquisition
Evaluation Methods**

This year, project members focused on completing and piloting the Software Proposal Evaluation Practices Questionnaire. This was the first step in the plan to develop a methodology for evaluating contractors' proposals for implementing software. To date, the questionnaire has been used to solicit data from five projects at the Air Force Systems Command, Electronic Systems Division at Hanscom Air Force Base; and one project at the Army Communications and Electronic Command (CECOM) at Ft. Monmouth, N.J.

The project was terminated in December due to lack of funding.

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**Software Process
Measurement**

The Software Process Measurement Project advocates the use of measurement in managing software development. The project is formulating reliable measures of the software development process and products to guide and evaluate development. To expedite DoD and industry acceptance, the project has convened a steering committee and two working groups, and has undertaken a best-practices study, all of which are devoted to encouraging organizations to use quantitative methods to improve their software processes.

This year, the Software Metrics Definition Working Group—composed of the Quality, Size, and Effort/Schedule subgroups—and the Software Acquisition Metrics Working Group held several meetings, peer reviews, and working sessions resulting in draft definitional documents. Project members and working group participants presented a summary of these documents at the 1991 SEI Affiliates Symposium and distributed the following documents for external review:

- *Software Project Effort and Schedule Measurement*
- *Measuring Software Quality Using a Problem Management System*
- *Software Size Measurement, with Applications to Source Statement Counting*

Measurement in Practice (CMU/SEI-91-TR-16) also was presented and released at the symposium. The draft document "Software Measurement Concepts for Acquisition Program Managers" was released for external review in October.

The project team hosted a meeting with the Measurement Steering Committee in September where future directions for the SEI measurement work were discussed.

Project members also initiated a working relationship with Naval Air Development Center (NADC) to collaborate on improving their measurement capability. Nine site visits were conducted to provide engineering support for this effort. This year's activities included providing assistance in beginning the NADC Software Measurement Process Action Team and jointly assembling a charter, measurement action plan, and an incremental build plan. A progress report documenting the 1991 SEI support activities for NADC was delivered to the client in December.

In the fall, a measurement kick-off meeting was held at Standard Systems Center, Gunter AFB, to discuss SEI assistance for SSC in defining and implementing a software process measurement system. Subsequently, a joint planning session was held with SSC in conjunction with the Software Process Definition Project.

An ad hoc working group of senior technical representatives from industry was convened at the Affiliates Symposium to discuss costs and benefits of proposed appendices for a Work Breakdown Structure for software within MIL-STD-881B. This request was made by Dr. Barry Boehm and the Joint Logistics Commanders, Joint Policy Coordinating Group on Computer Resources Management. The resultant information was summarized and assembled in an SEI report.

Project members were invited to participate in two meetings of the Computer Software Management Subgroup of the Joint Logistics Commanders (JLC) Joint Policy Coordinating Group on Computer Resources Management.

Project members made presentations and participated in the following workshops, symposia, and conferences:

- Software Metrics Implementation Panel at "San Antonio I" (fifth software workshop sponsored by the Joint Logistics Commanders, Joint Policy Coordinating Group on Computer Resources Management)
- International Society of Parametric Analysts Conference
- Third Annual Software Quality Workshop, cosponsored by Rochester Institute of Technology and Data & Analysis Center for Software
- National Aeronautics and Space Administration (NASA)/Goddard Software Engineering Laboratory Sixteenth Annual Software Engineering Workshop

The objectives of the Software Process Definition Project are to establish standard software engineering practice for the management and development of software and to advance the capabilities required to define and automate the software process within an organization. A "defined process" means that a process is documented, supported by training, and practiced, and that the practice, training, and documentation are generally found to be equivalent.

During 1991, the project supported process development efforts at SSC, Gunter AFB, and AMC. The project is also exploring advanced applications of process through the Defense Advanced Research Program Agency (DARPA) Software Technology for Adaptable, Reliable Systems (STARS) Program.

Project members planned and delivered a software process definition workshop entitled "Defining the Software Process—Getting Started" in support of their process improvement efforts. This workshop covered basic principles of process management, process improvement, process definition, and the descriptive modeling process. The workshop also included group exercises that allowed the participants to apply what they had learned and to plan how they would implement what they had learned.

In support of project sponsors who are engaged in process improvement activities, project members participated as active members of Software Engineering Process Groups (SEPGs) and process improvement working groups at sponsor sites. These activities ranged from facilitation to product development. During 1991, project

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**Software Process
Definition**

members assisted sponsor organizations in the development of process improvement working group charters and plans, descriptive process models, findings and recommendation reports, and other activities as requested.

The project initiated the development of a library of software processes as a participant in the DARPA/STARS program. The library will consist of reusable elements of software processes that can be composed to form project/product-specific software processes. The library will be based on experience-tested examples collected from industry and government. During this year, 26 examples were collected and catalogued, and community participation from 6 affiliate organizations was established through the SEI resident affiliates program.

In support of the DARPA/STARS effort and to promote community involvement in project activities, the project maintains an advisory group of more than 50 leading professionals from academia, government, and industry. The Process Definition Advisory Group (PDAG) provides guidance and helps maintain awareness of current research and state of the practice. The PDAG is providing support for the development of the DARPA/STARS software process asset library. In October, the project hosted a three-day search conference to establish requirements and concepts for the software process asset library. *The Process Definition Advisory Group Summary Report* (SEI-91-SR-15) summarizes the workshop results.

Project members served on the STARS Process Joint Activities Group as a Federally Funded Research and Development Center (FFRDC) facilitator. In this capacity, project members participated in the development of strategies, concepts, and plans that guide and direct the process component of the STARS effort.

A project member served on the Air Force Process Working Group as deputy chair. This group provides coordination and information exchange on process activities within the DARPA/STARS effort. Project members also served on the DARPA Process Steering Group.

Project members participated in the development of the STARS "Process Operational Concept Document," which serves as the technical foundation for the process component of the STARS environment.

Other activities included serving as the codeveloper of the software process modeling example problem for the Seventh International Software Process Workshop and Program Chair for 1992 Conference on Software Maintenance (November 1992).

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Software Process Research

The Software Process Research study will investigate factors that limit software development performance by conducting research on how software process principles are applied to individuals and small teams. This research in turn will provide further insight into the processes, tools, and methods that would be the most help to software professionals.

During the six months since the study started in mid-1991, some planning has been done. The findings of a research task on software defect prediction, with defect data from four major software organizations, are being prepared for publication.

Measurement in Practice

(CMU/SEI-91-TR-16)

Building Distributed Ada Applications from Specifications and Functional Components
(CMU/SEI-91-TR-22)

Capability Maturity Model for Software
(CMU/SEI-91-TR-24)

Key Practices of the Capability Maturity Model
(CMU/SEI-91-TR-25)

A Comparison of U.S. and Japanese Software Process Maturity
(CMU/SEI-91-TR-27)

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**Software Process
Reports**

1991

For information on ordering copies of SEI reports, see page 41.

Real-Time Systems

The goal of the Real-Time Distributed Systems Focus Area is to improve the development of real-time distributed systems by integrating software engineering with systems engineering and reducing the risk associated with new technology.

The Rate Monotonic Analysis for Real-Time Systems Project aims to ensure that rate monotonic analysis (RMA) and scheduling algorithms become part of the standard practice for designing, building, troubleshooting, and maintaining real-time systems. RMA helps engineers to understand and predict the timing behavior of hard real-time systems to a degree not previously possible.

Rate Monotonic Analysis for Real-Time Systems

Goals of the project include increasing the use of rate monotonic theory on highly visible projects, obtaining support for the rate monotonic approach from national hardware and software standards, and promoting the development of training and consulting resources outside the SEI. These targets are intended to serve as the major means for widely transitioning RMA techniques to real-time system developers.

As part of the goal to increase the use of rate monotonic theory on highly visible projects, project members are working closely with the prime contractor for the Navy's BSY-2 system, a major distributed system, to ensure the successful use of RMA.

Meetings with BSY-2 Nuclear Partition Group in Syracuse, New York have been scheduled to resume in January 1992. These meetings will continue the project's application of RMA to multiple coresident Computer Software Configuration Item (CSCI) in the Nuclear Partition software. Meetings have also been scheduled in January for BSY-2 subcontractors in Pittsfield, Massachusetts and Moorestown, New Jersey for continued analysis of individual CSCIs.

Project personnel attended a meeting in Moorestown, NJ to collect data pertaining to the I/O Controller/Post Processor (IOCPP) Executive, which is the executive software executing in the I/O controllers. This data will be used in performing an RMA of the IOCPP CSCI.

Project members are working with the Navy's Next Generation Computing Resource (NGCR) Program to encourage the development of a local area network (LAN) that adequately supports rate monotonic principles. Previously, the project had delivered an Ada binding to the SAFENET Lightweight Application Service definitions. The target implementation is the Xpress Transport Protocol defined by Protocol Engines Inc. The Ada binding is being revised and used as the basis for examining the development of an Inertial Navigation System (INS) node as part of a distributed system. A technical report discussing the use of the Ada binding to achieve a schedulable component is in preparation. The INS is an interesting example because of a stringent jitter requirement. In the course of this work, several issues in the transition of RMA to a distributed system have been identified.

Work is continuing in providing a high performance LAN via extensions to the IEEE 802.6 LAN standard. Project personnel made presentations to the Institute of Electrical and Electronic Engineers, Inc. (IEEE) 802.6 group regarding real-time network performance requirements, specifying the need for guaranteed bounded delay and jitter characteristics, as well as a minimum number of priority levels. Proposed protocol extensions are being reviewed and project personnel are currently developing a simulation model to verify the utility of the extensions in meeting the real-time network performance requirements.

Project members are also becoming involved with the POSIX.12 effort to develop a protocol-independent interface to a local area network. The Ada binding developed for the NGCR Program has application to this domain, particularly since it was developed for real-time mission-critical computer resource (MCCR) systems and directly supports scheduling principles, such as bounding the priority inversion that an application is willing to experience.

A project member reviewed the plan for the Patriot Missile ground control software upgrade to advise the project on its use of Ada and to evaluate the potential use of rate monotonic scheduling theory in designing this software. A student in the Master of Software Engineering (MSE) program from Raytheon, the contractor handling the Patriot Missile, is familiar with this software and will be undertaking an RMA of its design as part of his independent study program in the spring 1992 term. This will allow RMA principles to be transitioned to the Patriot Missile software project.

Project members continued working toward the long-range goal of producing a Real-Time Systems Engineering Handbook. The goal of the handbook is to codify the principles of RMA in a manner that is easily accessible to real-time systems practitioners.

The current design of the handbook has three main components:

- A section that describes a framework for classifying timing problems commonly faced by real-time system designers.
- A collection of real-time coding paradigms for a selected set of real-time problems and the associated timing analysis.
- Case studies to illustrate how RMA can be used to analyze the timing behavior of realistic real-time systems.

The project is also in the process of planning for external review of an early draft of the handbook.

Project members continued to work with the Advanced Real-Time Technology Project at Carnegie Mellon University (CMU).

Project members participated in the review of performance problems at Atlantic Aerospace. After giving a brief tutorial of RMA methods, the software designers appeared to appreciate how it could be applied to solve their system problems. They will be reporting their progress to project members.

As part of the MSE Project, a group of four students will be developing a tool to assess schedulability of a task set and generate an associated benchmark based on an application specification language.

The project discovered a commercially available tool set that performs a limited level of RMA. Additionally, project members have talked with several other computer-aided software engineering (CASE) tool vendors about the possibility of having their tools support RMA.

The project is also pursuing the university academic system as a channel for transitioning RMA. Project members have been collaborating with several universities as they incorporate RMA into their curricula. In particular, Ruth Ravenel of the University of Colorado has given several lectures on RMA to graduate students.

The project has discovered several examples of RMA adoption within the marketplace. At the Tri-Ada 91 conference, promotion materials by Telesoft advertised "hard deadline scheduling, based on Rate Monotonic Scheduling as defined by the SEI;" for over a year, an Ada training company (Absolute Software) has included rate monotonic scheduling concepts in two of its courses; and a Swedish company (Saab Space) has designed a microprocessor that supports RMA and rate monotonic scheduling algorithms, such as Priority Inheritance. At the IEEE Real-Time Systems Symposium, several research paper presentations discussed rate monotonic concepts, such as priority inversion, priority inheritance, rate monotonic scheduling, and the priority ceiling protocol (PCP). In fact, one of the papers proposed an extension of PCP, called a Conditional Priority Ceiling Protocol (CP). Additionally, several real-time practitioners, in brief presentations, discussed the use of RMA. Some of these included representatives from IBM, Magnavox, NASA, and Computer Sciences Corporation.

A paper documenting extensions to current analytical methods for assessing schedulability was presented in December at the 1991 IEEE Real-Time Systems Symposium. The paper is currently being extended for submission to a special issue of IEEE Transactions on Software Engineering.

An interim progress report was submitted to the BSY-2 Project Office as part of the BSY-2 TO&P deliverables

The Real-Time Embedded Systems Testbed (REST) Project is collecting, classifying, generating, and disseminating information about Ada performance issues in hard real-time embedded systems.

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**Real-Time Embedded
Systems Testbed**

Building real-time systems, particularly embedded and distributed real-time systems, is currently a craft rather than a structured, methodical endeavor. Tools, including the Ada programming language and the accompanying Ada runtime support facilities, are only beginning to fulfill their promise for raising the level of abstraction for real-time programming. Use of such tools is still perceived as entailing a high degree of risk. One of the problems addressed by REST is the identification and the reduction of such risks.

At this time, the government does not routinely assess the quality of Ada compilation systems. Both Ada users and vendors need help to improve the quality of such systems. The identification, development, and distribution of techniques and tools to help improve Ada implementations is another problem addressed by REST.

This year, the project continued to refine the detailed design of the Hard Real-Time (Hartstone) Benchmark Suite by performing experiments toward the implementation of the Periodic Non-harmonic (PN) benchmark, the next program in the series. Minor discrepancies with the PN series were corrected in preparation for the delivery of the next release in July 1992. The REST transition approach will be based on the ACM SIGAda Performance Issues Working Group (PIWG) model.

In support of BSY-2, the project is investigating the performance impact of Ada style using the U.S. Ada Compiler Evaluation Capability (ACEC), the UK Ada Evaluation System (AES), and PIWG assessment software. Problems with the benchmark suites were documented. The Ada Program Generator and the GROW stress test generator were installed on the testbed. The REST part of the interim report for BSY-2 was produced, reviewed and delivered. The structure of a draft of the final technical report was agreed upon. The document will critique the BSY-2 Ada style guide from a performance standpoint.

Project members actively participated in the work of ACM SIGAda Ada Real-Time Environment Working Group (ARTEWG) and PIWG. A major purpose of these activities is the support of the Ada 9x process focusing on the needs of the Ada real-time community.

This year, the project began developing an on-line catalog of major references in the field, with the goal of regularly producing annotated bibliographies of selected papers and publications.

Since a memorandum of understanding has been signed between the U.S. and the U.K. to merge the U.S. ACEC and the British AES suites of benchmarks, REST organized and co-sponsored a workshop to study the technical issues involved. The workshop took place in San Diego in January, 1991. REST findings from a year of intense experimentation for BSY-2 were presented. REST has been identified as a beta test site for release 3.0 of the ACEC. Some preliminary findings were shared with the developers at the workshop. Timing accuracy determination experiments were started and the outline of a technical report contrasting ACEC/AES and PIWG timing techniques was drafted.

The project distributed the proceedings of the MIL-STD-1750A and Ada workshop organized at JPL in June, 1991.

RMARTS and REST are cooperating in developing benchmarks necessary for the RMA of real-time system software, as well as guidelines for the creation of such benchmarks. Using the Real-Time Computing Network (RTCN) as a test system, we have identified a set of parameters to be measured and are currently implementing preliminary benchmarks.

Together with the Distributed Systems (DS) Project, REST is testing the Durra software previously ported to the RTCN hardware, which is on loan from IBM. Benchmarking of the communication primitives was started.

The project provided advice, software, and relevant technical material to the Radar Software Improvement Program for the U.S. Air Force. REST reviewed the evaluation plan and participated in weekly teleconference calls and in meetings at Westinghouse Electric Company in Baltimore, Maryland.

Collaborative work with the Comet Rendezvous Asteroid Fly-By and Cassini missions of NASA Jet Propulsion Laboratory continued. REST participated in the preliminary design review for the flight system.

Members of the REST Project attended the Strategic Avionics Technologies Working Group (SATWG) meeting at Lockheed in Nashua, NH. The SATWG is a senior advisory group to NASA and the DoD.

REST participated in Tri-Ada 91 in San Jose, California. A subset of the project tutorial on Ada evaluation technology was offered at the PIWG meeting to prime a debate about the relative merits of the ACEC and the AES. Remarks made by those who attended that meeting were used during the ACEC/AES merger workshop.

In cooperation with the DS and RMARTS Projects, REST project members defined and proposed a joint project for the software development studio of the MSE Program. Durra would form the basis of a tool set designed to experiment with schedulability analysis and automatic benchmark generation. This was the occasion to establish a closer cooperation with vendors such as Tartan and with several universities, such as the University of Michigan.

The Distributed Systems Project (formerly Software for Heterogeneous Machines) is developing tools and a methodology for building distributed, large-grained, concurrent applications to run on networks of heterogeneous machines. The project has developed Durra, a language for describing distributed applications as a set of task descriptions and port connections. The Durra compiler generates Ada program units that link clusters of application tasks as executable programs. A library package provides application/location independent communication facilities to the application tasks.

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Distributed Systems

Project members completed a number of technical reports describing the new implementation of Durra and its use as a prototyping environment. One of the reports was presented at TRI-Ada 91 and was nominated for the best paper award.

Project members submitted a paper to the International Workshop on Configurable Distributed Systems, organized by Imperial College, London, England. The paper was accepted for presentation at the workshop, which will take place in March 1992. In addition, Mario Barbacci was invited to participate on an expert panel at the workshop.

Project members continued to work with members of the REST and RMARTS projects and students in the MSE Studio to define a studio project focused on automatic generation of application benchmarks and Rate Monotonic schedulability analyses.

Dennis Doubleday continued to serve as a technical reviewer with the IEEE POSIX 1003.5 WG (Ada binding to 1003.1, the POSIX System API). In October, the SEI hosted a meeting of the 1003.5 Ballot Review Committee. At that meeting, the committee resolved outstanding ballot objections from the initial circulation of the draft standard (Draft 6) and completed Draft 7 of the document, which was recirculated for ballot in late November. An approved standard is expected in early 1992.

Mario Barbacci was elected to the Board of Governors of the Computer Society. He was also appointed to the Board of Governors of the Federation of Computing Societies of the U.S. (FOCUS). FOCUS is the U.S. representative at the International Federation For Information Processing and replaces the now defunct American Federation for Information Processing.

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Virtual Reality

The Virtual Reality Feasibility Study is concluding at the end of December 1991. The conclusions of the feasibility study are that virtual reality is an important area and one the SEI should be exploring. Such an exploration makes the most sense in the context of an application area. One important application area, both for virtual reality and in general, is real-time simulation. As a result of this and other reasons, the Virtual Reality Feasibility Study is recommending that the SEI establish a Real-Time Simulation Project that has virtual reality as one of its components.

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Systems Fault Tolerance

The Systems Fault Tolerance Project is in the feasibility stage, investigating the need for fault tolerance technology in the design and implementation of software-intensive dependable or critical systems.

A report documenting the results of the Fault Tolerant Systems Practitioner's Workshop held at the SEI on June 10-11, 1991, was completed. A paper summarizing the report was submitted to the 22nd International Symposium on Fault Tolerant Computing, and a panel session consisting of workshop participants was proposed.

The project has been invited to participate in the Fault Tolerant Mach (FTM) Project, a three-year effort conducted jointly by the CMU School of Computer Science and the CMU Electrical and Computer Engineering (ECE) Department. FTM is an experiment in modular, fault tolerant operating systems. FTM will be designed to survive a wide variety of error manifestations generated by diverse error sources. It will be implemented on the existing Mach operating system and its real-time thread model by building a set of fault tolerant operating system functions at the Mach application (transparent library) level. The basic Mach design is expected to remain unchanged. At this time, the FTM group is defining the basic capabilities of the first FTM increment.

The project has begun work on a framework to provide a consistent view of how systems fail and how various fault tolerance approaches are related. The project intends to invite recognized experts in fault tolerance to visit the SEI for short periods during 1992 to review and refine the framework.

The project is continuing discussions with the NADC regarding the development of guidelines for high-dependability systems as part of the Navy NGCR program.

The project hosted three lectures in the Distinguished Lecture Series in Fault Tolerance this period: Dr. Faye Briggs, Director of Advanced Development, Tandem Computers, Inc., spoke on "Computing Technologies in the 1990s," Dr. W. C. Carter, a pioneer in fault tolerance, spoke on "Can We Rely on Fault Tolerant Systems?," and Dr. Jean-Claude Laprie, a director at CNRS-LAAS, Toulouse, France,

spoke on "New Developments in Software Reliability Analysis, Modeling, and Prediction." We expect to make copies of the tapes and lecture notes of all three lectures available.

The objective of the Zero-Defect Application Kernel (ZDAK) Project is to improve the state of practice for handling software fault tolerance in the area of real-time mission critical systems. The ZDAK project, currently in its embryonic stage, has two aspects. First, ZDAK will continue supporting RMARTS project since RMA will be a basic building block in real-time fault tolerant systems. Second, ZDAK will focus on forming a critical mass for the development of the ZDAK core technology.

In the area of supporting RMARTS project, an important effort is to work with a CMU PhD candidate in the extension of RMA theory for the scheduling of wide area network. This work addresses the distributed real-time scheduling problem, where no node will have complete information about the system state. The results of this work will serve as the theoretical foundation for suggesting modifications to the IEEE Wide Area Network Standard (IEEE 802.6) for supporting real-time applications. In addition, Lui Sha has responded to calls for assistance in the real-time community. This includes reviewing a portion of the designs of NASA's Space Station program, a portion of the designs of Federal Aviation Administration (FAA) Advanced Automation System (AAS), and a radar system design by Atlantic Aerospace Electronics Corp.

In the effort of developing the core technology for the ZDAK project, Lui Sha, Professor John Lehoczky (CMU Statistics Department), and Professor Marc Bodson (CMU ECE Department) submitted the final version of their overview paper, "The Simplex Architecture: Using Analytical Redundancy for Software Fault Tolerance," to the 1991 First International Workshop on Responsive Systems. This paper provides an overview of the approach to be used by ZDAK and will appear in the workshop proceedings. Additionally, Lui Sha accepted the invitation to be a member of the programming committee of the 1992 Second International Workshop on Responsive Systems.

The Office of Naval Research (ONR) has funded ZDAK. IBM Federal Systems Division (FSD) sent Lui Sha their radar gateway design for the FAAs AAS project. The radar gateway design will be used as a possible testing case in ZDAK's investigation of software fault tolerance technology. Lui Sha chaired the 1991 IEEE Real-Time System Symposium and was recognized as a Senior Member of the IEEE.

Generic Avionics Software Specification
(CMU/SEI-90-TR-8)

Rate Monotonic Analysis for Real-Time Systems
(CMU/SEI-91-TR-6)

Issues in Real-Time Data Management
(CMU/SEI-91-TR-17)

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**Zero-Defect Application
Kernel Project**

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**Real-Time Systems
Reports**

1991

Durra: An Integrated Approach to Software Specification, Modeling, and Rapid Prototyping

(CMU/SEI-91-TR-21)

An Application-Level Implementation of the Sporadic Server

(CMU/SEI-91-TR-26)

Serpent Overview

(CMU/SEI-91-UG-1)

Serpent: System Guide

(CMU/SEI-91-UG-2)

Serpent: Saddle User's Guide

(CMU/SEI-91-UG-3)

Serpent: Dialogue Editor User's Guide

(CMU/SEI-91-UG-4)

Tool Integration and Environment Architectures

(CMU/SEI-91-UG-5)

Serpent: Guide to Adding Toolkits

(CMU/SEI-91-UG-6)

Serpent: Ada Application Developer's Guide

(CMU/SEI-91-UG-7)

Serpent: C Application Developer's Guide

(CMU/SEI-91-UG-8)

A Comparison of Ada 83 and C++

(CMU/SEI-91-SR-4)

Fault Tolerant Systems Practitioner's Workshop, June 10-11, 1991

(CMU/SEI-91-SR-13)

For information on ordering copies of SEI reports, see page 41.

Software Engineering Techniques

The primary objective of the Software Engineering Techniques Focus Area is to improve the practice of software engineering by improving individual and team productivity through the identification and transition to practice of emerging software technology. Promoting the appropriate use of this technology supports the SEI effort to transform software development from an ad-hoc, labor-intensive activity to a technology-supported engineering discipline.

To develop a fundamental understanding of structures for the software architecture level of design, the Software Architecture Design Principles Project is describing basic design elements used in the description, analysis, and development of software systems.

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**Software Architectures
Design Principles**

During 1991 the following papers were published this year:

- *Models for Undergraduate Project Courses in Software Engineering*, for the Fifth SEI Conference on Software Engineering Education. It was also published as a technical report (CMU/SEI-91-TR-10).
- *Heterogeneous Design Idioms for Software Architecture*, for the Sixth International Workshop on Software Specification and Design.
- "Informatics for a New Century: Computing Education for the 1990s and Beyond," *Education and Computing*, 7 (1991), 9-17. This paper was previously published as a technical report (CMU/SEI-90-TR-15). Bellcore has asked that this paper be published in an executive anthology they are assembling.

During 1991, *Prospects for an Engineering Discipline of Software*, published in IEEE Software and as technical report CMU/SEI-90-TR-20, was named one of the three best papers in IEEE Software in 1990. Additionally, at the International Conference on Software Engineering, the project leader accepted an award for the most influential paper from ICSE-2. In her acceptance speech, the project leader reviewed the history of abstract data types.

The task of identifying architectural constructs has progressed sufficiently to begin articulating this new area to potential recipients of models and tools. To this end, project members made the following presentations:

- "Models for Undergraduate Courses in Software Engineering," Massachusetts Institute of Technology/Pew Foundation Workshop on Computer Science Curriculum.
- "Larger-Scale Systems Require Higher-Level Abstractions," Massachusetts Institute of Technology and University of Massachusetts at Amherst.

During 1991, the project leader presented a paper on software engineering education at a workshop in conjunction with the International Conference on Software Engineering held in Austin, Texas. The project leader also prepared and presented a distinguished lecture at Massachusetts Institute of Technology, The CMU School of Computer Science Distinguished Lecture Series, and the High Integrity Systems Series at the National Institute of Standards and Technology. This lecture which was a revision of *Software and Some Lessons from Engineering*, as appeared in the technical report entitled *Prospects for an Engineering Discipline of Software*.

In addition to these accomplishments, the project leader also participated in the Information Science and Technology Study Group (Information Science and Technology Office, DARPA), the Computer Science and Telecommunications Board of National Research Council, the Board of Visitors (Computer Science Division, Office of Naval Research), the Panel for National Computer Systems Laboratory (Board on Assessment of National Institute of Standards and Technology Programs, National Research Council), the Advisory Board for Office of Technology Assessment's Intellectual Property Project, and also in the Infrastructure Project of the Office of Technology Assessment.

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**Software Architectures
Engineering**

The Software Architectures Engineering (SAE) Project has been involved in the engineering of software in several critical DoD application areas for the last five years. The project goal is to use sets of identified patterns together with engineering design goals to provide guidelines for building the basic elements of software structure (models). The project is currently focusing on three aspects of this technology: the generalization of software models by providing templated structural elements and connection rules that invest the implemented software with the desired product qualities; the naturalization of the models so that real-world components have corresponding software analogs; and the application of tools and notations to software development based on generalized structures.

The SAE Project provides DoD program offices with improvements to the practice of software engineering by assisting in the creation and adoption of model-based technology. The project accomplishes these improvements by helping clients to abstract the desirable software architecture characteristics for particular classes of applications and to use them to create reusable patterns of software structures specific to an application. Project members refine and mature the new models by transferring them to other projects, which provides additional sources of feedback on their use.

SAE has recognized that most software-dependent systems have aspects of control systems in them. As a result, a near-term focus of the project is to define and populate a technology base of engineering models for control systems software. The models and rules of composition that make up the models in the technology base will be applicable to all of the application areas in which SAE is involved.

The SAE Project has been working with the Air Force Electronic Combat Office (AFECO) and the Tri-Service CROSSBOW-S organization on the Joint Modeling And Simulation System (J-MASS). J-MASS currently relies on the SAE Project's

model-based software development concepts and the Object-Connection Update (OCU) architectural model as the basis for simulation models used within the system. SAE project members are participating as members of the J-MASS design team.

In early 1991, SAE project members delivered a special report to AFECO, *Definition of Engineering Requirements for AFECO—Lessons from Flight Simulators*, which discusses the requirements for electronic combat simulation systems and puts the development of such systems into an engineering context.

Throughout 1991, SAE project members worked with J-MASS developers to refine the OCU model and investigate tooling issues. One result of this work is a composition tool which, when given subsystem or component specifications, produces Ada code based on the OCU. In the Fall of 1991 this tool, developed by Dynetics, Inc., was used by the developer to generate 100,000 lines of code out of a total of 130,000 lines of code for a radar system model to be used in the J-MASS application.

In August 1991, SAE was asked by AFECO to become involved in an AFECO-sponsored project to establish a common software architecture for Electronic Combat Test Facilities. Like J-MASS, these facilities involve electronic warfare simulation. Unlike J-MASS, the simulations are real-time. During the Fall of 1991, SAE project members worked with AFECO and the project contractor, Ball Systems, to establish a model basis for simulation executives and electromagnetic environment simulations.

In 1991, SAE was asked by the Defense Modeling and Simulation Office to participate in an effort to establish a battlefield simulation infrastructure. To date, SAE project members have participated as members of the Defense Modeling and Simulation Office (DMSO) Software Engineering Technical Working Group. In addition, work has begun on a report to DMSO that outlines the software architectural issues in simulation systems.

SAE project members continue to work with the Naval Coastal Systems Center (NCSC) on the AN/SSQ-94 Combat System Integrated Training Equipment (CSITE) Program. The program will develop classroom, dockside, and ship-based systems for mine detection and countermeasures training.

Together with a resident affiliate from NCSC, project members developed a four-day course for training NCSC software developers in the adaptation and use of the OCU architectural model. The course was delivered April 22-25, 1991, in Panama City, Florida. The NCSC resident affiliate finished his full-time commitment with the project and began participation in the SEI MSE program in September 1991.

SAE helped form the CSITE Architecture Working Group (AWG). The major responsibilities of this group include evolution and control of the:

- AN/SSQ-94 CSITE architectural model
- AN/SSQ-94 CSITE application design
- Software development plan

SAE is a participating member of the group and provides expertise based on five years of experience engineering software systems. This working group will be the vehicle for transferring the model-based expertise of SAE into the NCSC community. AWG meetings were held on June 17-18, and on August 26 at the SEI. The design decisions resulting from these meetings have been captured and documented in

Minutes of the AN/SSQ-94 Architecture Working Group. The frequency of these meetings was reduced for several months due to restructuring, refocusing, and prior commitments within NCSC. Regular meetings have now resumed. The reemergence of the working group in November and December was encouraged and supported by Lyle Burnett, CSITE Program Manager.

Project members also are working with members of the DARPA Domain-Specific Software Architectures (DSSA) Program. This research program recently began funding six industrial/academic teams focusing on software architecture development in DoD critical domains.

In 1991, SAE attended the DARPA DSSA kick-off meeting in July and began discussions with the six teams on software architectural issues. The SAE Project will provide technical support to the program, such as coordinating a common engineering viewpoint across the teams. In addition, SAE project members will transfer the control systems developed in their work with AFECO, DMSO, SEMATECH, and NCSC to the DARPA DSSA community.

SAE is writing part of a joint SEI proposal, with SEMATECH, to participate in engineering modeling work for software-dependent control systems in the Computer Integrated Manufacturing (CIM) application area. An initial demonstration effort will focus on defining a set of models for a number of similar software-dependent machine tools supplied by one of the SEMI/SEMATECH equipment suppliers. The results will be generalized to the broader CIM community and possibly to the manufacturing systems community in general.

SAE project members met with the SEMATECH Control Systems Engineering (CSE) group in October and December. CSE is involved with a semiconductor equipment supplier to define and build an integrated set of process tools for lithography and tracking. The technology embodied in these tools will support 0.25 micron wafer processing at a production rate significantly above current systems. The window of opportunity for this tool is within the next two years. SAE will work with CSE and the equipment supplier to develop machine and cell-level software-dependent control systems.

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**Software Development
Environments**

The Software Development Environments (SDE) Project focuses on environment support for software configuration management (SCM) and on environment architectures in support of integration.

Regarding SCM support, the project has identified the state of commercial technology that has been captured through a spectrum of concepts and four observed paradigms. Configuration management (CM) capabilities can be found in SCM tools, CASE tools, and environment frameworks, each implementing its own variant of some of the concepts. This variety leads to the need to integrate tools with different SCM capabilities into a software development environment, and the desire for a unified SCM model that can be adapted to different processes. The result is project activity in issues of consolidation of SCM concepts, integration of SCM and CASE tools, and SCM support for the CM process and its relationship to the CMM.

The needs for integration of SCM and CASE, as well as a number of emerging environment technologies, have led to increased project activity on environment architectures in support of integration. A number of government and industry efforts are focused on environment reference models and interface standardization.

The project communicated its findings on a framework for SCM concepts and the observed SCM models in several forums. Project members presented a tutorial entitled, "State-of-the-Art in Environment Support for Configuration Management," at the 13th International Conference on Software Engineering (ICSE13). The project leader served as the program chair for the Third International Software Configuration Management (SCM3) Workshop. The paper, "Concepts in Configuration Management Systems," was the keynote presentation at SCM3 and was published in the proceedings. A summary of CM work in the CAD arena was also presented at SCM3. A paper entitled, "CM Models in Commercial Environments," summarizes four observed paradigms. In addition, a seminar series given at a sponsor site consisted of the state of SCM support, the state of CASE integration, and issues in CASE and SCM integration, leading to a strategy for SCM in a CASE environment.

Project members are investigating the state of environment integration, including technologies such as Broadcast Message Services and the Portable Common Tool Environment (PCTE). They have reported the initial findings in reports and presentations including:

- *Past and Future Models of CASE Integration*
- *Tool Integration and Environment Architectures (CMU/SEI/91-TR-11)*
- *Understanding Integration in a Software Development Environment*
- *Case Studies in Environment Integration (CMU/SEI-91-TR-13)*

Project members have been active participants in the STARS effort, the National Institute of Standards and Technology (NIST) Integrated Software Engineering Environments (ISEE) effort, and the NGCR Project Support Environment Standards Working Group (PSESWG) effort. In the NIST ISEE effort, which focuses on a environment framework reference model (known as the NIST/ECMA [European Computer Manufacturers Association] reference model) and standardization, project members provided working group leadership on the topic of integration. In the NGCR PSESWG effort, project members provided the technical lead in the development of a reference model for complete project support environments. A presentation at STARS91 captured this ongoing work. Project members also are involved in a lessons learned effort of previous government efforts in environments, which is performed jointly with the CASE Technology Project.

Project members have participated in the process management working group of NIST ISEE. The NGCR PSESWG reference model work reflects the relationship between environments and process. A paper entitled, "Process Development and Enactment: Concepts and Definitions," provides a basis for common terminology in the software process community. The project leader is a member of the program committee and the example chair of the Eighth International Software Process Workshop (ISPW8).

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Domain Analysis

The Domain Analysis Project is currently analyzing the Army movement control domain to discover and exploit commonality. The project is using the Feature-Oriented Domain Analysis (FODA) method, developed by the project in 1990, to perform this analysis. The analysis provides a model of applications within the domain that can be used for understanding the design of those applications and to support the development of new movement control software. The analysis will also serve as a means of improving the FODA method. The results of this analysis are described in a special report, currently in draft form, that will be available in early 1992.

Early in 1991, project members presented a tutorial on Software Reuse Technology at Tri-Ada and at the Ninth Annual Conference on Ada Technology. Project members also hosted a successful workshop to review the methods and results to date of domain analysis. Participants represented several Army research and development organizations as well as contractors actively working in movement control.

The project is currently working with Army customers who will use the domain model as a basis for implementing new software systems. Project members are actively working with CASCOM (Combined Arms Support Command) and their material developer, ISEC (Information Systems Engineering Command) Software Development Center, using the model in development of the Department of Army Movement Managements System—Redesign (DAMMS-R). The domain model will be used in both the Operational Movement Program and Highway Operations Team subsystems of DAMMS-R. Project members are also planning to use the model in support of movement control specification for ATTCS (Army Combined Arms Support Command) systems. The SEI will use the model as a basis for designing reusable software packages to be used initially for DAMMS-R and subsequently for ATCCS battlefield functional area systems.

Members of the project are currently working with the Central Archive for Reusable Defense Software (CARDS) to evaluate library effectiveness in supporting domain and architectural models. The Air Force test case is the command center domain as represented by ESDs Generic Command Center architecture. Project members will use both CARDS and the SEI domain analysis methods to represent this domain and compare the effectiveness of each technique. We also will use the CARDS tools to represent the Army domain.

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Domain-Specific Software Architectures

The Domain-Specific Software Architectures (DSSA) Project advances the use of structural models to develop software with predictable quality and cost and the maturation of a structural modeling technology base.

This year, project members continued transition of the Special Operations Forces Aircrew Training System (SOF ATS) to structural modeling. The program's preliminary design review (PDR) proved to be the showcase for structural modeling that it was intended to be. The PDR was attended by representatives of DoD commands and program offices. Attendees were impressed by the power of structural modeling.

Project members also continued refining the OCU structural model for real-time simulators, focusing on the use of rate monotonic constructs to execute rate groups with transparent resolution of the data coherency problem.

The Aeronautical Systems Division, Deputy for Simulators (ASD/YT)-Industry Steering Group briefed industry chief engineers on the application of structural modeling to simulators. The briefing featured speakers from ASD and its contractors, all relating experiences with structural modeling. The briefings reflected both the favorable impressions about structural modeling and the sense that structural modeling is maturing. ASD/YW reconfirmed its commitment to involve the SEI in the creation of an Air Force guidebook to disseminate lessons learned from the extensive use of structural modeling. Work on the guidebook will proceed under a new, long-term technical objectives and plans (TO&P).

This year, project members continued working with SEABAT, the developers of the BSY-2 Basic Operator Trainer (BOT). The SEABAT team has calibrated its structural model and created a set of forms for specifying requirements in the context of the structural model spreadsheets for conducting model-based estimation of resources.

The Requirements Engineering Project is conducting a survey of the methods, tools, and processes necessary for elicitation, analysis, and validation of requirements for software-intensive systems. The purpose of the survey is to have a broad understanding of requirements engineering technologies and to identify techniques that have been applied successfully.

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**Requirements
Engineering**

In March of 1991, the project hosted a requirements engineering workshop. The workshop provided a forum for gaining insight into requirements issues, understanding the problems organizations have, identifying their needs, reviewing previous results with practitioners, and establishing productive future directions for research efforts. The proceedings of the workshop were published in an SEI special report. Also, as a result of the workshop, project members developed a project plan. The project plan focuses on requirements elicitation and prototyping techniques, and the integration of these techniques into a requirements engineering handbook. The plan is currently being reviewed.

The CASE Technology Project focuses on improving the ability of SEI sponsors and affiliates to make informed decisions about tool adoption and to improve their practice in the use of CASE tools. It also provides information to tool vendors on current tool usage and gaps in current technology.

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CASE Technology

The project conducted periodic workshops to consider critical issues in the CASE area and to provide a forum for vendors and users to address underlying issues in an objective setting. A workshop held in November 1990 focused on the CASE adoption process and roles. A second workshop in June 1991 addressed several management issues in adopting CASE technology, including acquisition issues and selection issues.

These workshops and other efforts have provided the material for a series of products under development that are focusing on tool strategy and tool adoption. A video on CASE adoption issues was developed recently in conjunction with the continuing education course in software project management.

The project began a new effort in support of the SSC at Gunter AFB. This effort is gathering lessons learned from previous government-sponsored efforts at building or acquiring environments or tools. Through this effort, the project has also reviewed the plans of the SSC and provided feedback on the SSC tool strategy.

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**Software Engineering
Techniques Reports
1991**

Spectrum of Functionality in Configuration Management Systems
(CMU/SEI-90-TR-11)

CASE Tool Integration and Standardization
(CMU/SEI-90-TR-14)

Transaction-Oriented Configuration Management: A Case Study
(CMU/SEI-90-TR-23)

Tool Version Management Technology: A Case Study
(CMU/SEI-90-TR-25)

Formal Development of Ada Programs Using Z and Anna: A Case Study
(CMU/SEI-91-TR-1)

Configuration Management Models in Commercial Environments
(CMU/SEI-91-TR-7)

Issues in Tool Acquisition
(CMU/SEI-91-TR-8)

Models for Undergraduate Project Course
(CMU/SEI-91-TR-10)

Tool Integration and Environment Architectures
(CMU/SEI-91-TR-11)

Case Studies in Environment Integration
(CMU/SEI-91-TR-13)

Process Specification for Post
(CMU/SEI-91-TR-15)

Prospects for an Engineering Discipline of Software
(CMU/SEI-90-TR-20)

A Critical Review of the Current State of IPSE Technology
(CMU/SEI-91-TR-29)

A Domain Analysis Bibliography
(CMU-SEI-90-SR-3)

For information on ordering copies of SEI reports, see page 41.

Special Projects

The Transition Models Project is developing a set of methods and support materials such as guidelines and checklists for planning, implementing, and assessing transition activities. These materials will be used by software technology producers and consumers both inside and outside the SEI. The Transition Models staff also provides other SEI staff and management, with education and training on technology transition concepts and approaches.

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Transition Models

Project members provide limited consulting on software technology transition to members of the SEI constituencies, and maintain contact with researchers and others interested in technology transition from business and academic domains.

From January through August, Priscilla Fowler, leader of the Transition Models Project, coordinated SEI technical support for the development of the DoD Software Technology Strategy (SWTS). Fowler attended monthly planning and writing meetings in Washington, DC with other members of the SEI team. In addition, she contributed draft sections for and comments on the chapters addressing technology transition of the SWTS.

Project members and John Maher, an SEI member of the technical staff, developed a tutorial on software technology transition. The tutorial includes material on managing technology maturation and adoption, managing technology innovation in an organizational context, and developing an organizational strategy for technology transition. Models of technology transition that are the basis for the guidelines and check lists on transition were described in the tutorial, thus consolidating early project work and earlier experience. The tutorial was presented at the 13th International Conference on Software Engineering, held in May in Austin, Texas. It was presented again at the SEI in July for attendees from the U.S. Air Force Computer Resource Management Technology effort, Hewlett Packard, SEMATECH, and the SEI. Copies of the tutorial, which includes slides with notes and a bibliography, were distributed to attendees at the poster session held by the project at the SEI Affiliates Symposium in August.

The Transition Models project has supported the STARS program in a number of areas related to technology transition. In January, the project performed an analysis of STARS technology transition planning. Priscilla Fowler and Stan Przybylinski presented the results of this analysis, along with an excerpt of an early version of the Software Technology Transition tutorial, to the STARS Joint Architects Team in Washington, D.C. in mid-February. In late February, the same presentation was made to STARS program management, service representatives, and support contract personnel at UNISYS in Reston, Virginia. Project members planned and facilitated the STARS Vision Workshop with the STARS Program Director and Program Architects on April 14-18, and a follow-up workshop on May 16-17. At the request of the STARS Joint Architects Team, Stan Przybylinski reviewed the previous issues

of the STARS Program newsletter to provide constructive feedback on how to improve the publication in subsequent issues. The suggested changes were implemented. A mini version of the Software Technology Transition tutorial was presented at the STARS 91 conference in December.

In July, Priscilla Fowler hosted a technical interchange meeting with representatives of Hewlett Packard to discuss approaches to intraorganizational technology transfer and process improvement. Members of the SEI Process and Risk Programs and a representative of SEMATECH also participated. Also in July, Fowler met with members of the Institute for Defense Analyses (IDA) to discuss definitions of transition mechanisms offered by Fowler for a draft of the SWTS. These definitions will be used by IDA in a survey of government departments and their technology transition efforts. In November, technical interchange meetings on technology transfer were held with Claude Del Fosse and Wilfred Spencer of the Software Productivity Consortium, and with William Smith of the Electric Power Research Institute.

Fowler and William Smith, Electric Power Research Institute, jointly organized a symposium on technology transfer sponsored by the Council of CEOs (chief executive officers) of Consortia, of which SEI Director Larry Druffel is a member. The symposium was held in November at the SEI and was attended by representatives from Electric Power Research Institute, MCNC (formerly Microelectronics Center of North Carolina), Microelectronics and Computer Technology Corporation (MCC), National Center for Manufacturing Sciences, SEMATECH, Semiconductor Research Corporation, the SEI, and the Software Productivity Consortium. Invited talks were given by Dr. Louis Tornatzky of the Industrial Technology Institute and Dr. Robert Meyer of the Gas Research Institute. Each representative had executive or line management responsibility for technology transfer. Several informal working groups in areas of common interest were formed and additional meetings are planned; the next meeting is scheduled to be held at MCC.

The Transition Models Project sponsored a poster session at the SEI Affiliates Symposium. Contact information was obtained from approximately 150 people, who received copies of tutorial notes from the project tutorial on Software Technology Transition. The contact information has been converted to a preliminary project mailing list of those interested in software engineering technology transition.

Project members have been working with members of the RMARTS Project to plan a transition of RMA for the purpose of alpha testing approaches to software technology transition developed by the Transition Models project. A series of interviews has been conducted with Tom Ralya, a member of the RMARTS Project, who has had extensive experience transferring RMA into a large contractor organization. A chronology of events has been prepared and an analysis begun of the evolution of the RMARTS project.

Staff from the Transition Models Project, along with staff from the SEI Process Program and the Software Architectures Engineering Project, have participated in a planning effort for a collaboration with SEMATECH. The planning activity is being coordinated by Ken McNulty of the Program Development Division. Priscilla Fowler visited SEMATECH with McNulty in October to present detailed information on the Transition Models Project to members of SEMATECH.

The Transition Models Project prepared an analysis of all current SEI work and related transition activities, using the technology maturation phases from the 1984 IDA report on software engineering technology transition. This exercise was begun at the request of Neil Eastman of the SEI Board of Visitors and is being continued for the purpose of gaining better understanding of technology maturation issues in the SEI context.

The Empirical Methods group supports technology development, assessment efforts, and SEI technology projects by providing market research methods and materials, conducting surveys, and evaluating events or validating products of SEI projects. In addition, the group conducts the National Software Capacity Study.

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Empirical Methods

During 1991, Empirical Methods staff and colleagues from the Carnegie Mellon School of Urban and Public Affairs collected data for three upcoming reports for the National Software Capacity Study:

1. Estimates of post-deployment software support (PDSS) status for the DoD
2. International software production
3. Unintended effects of acquisition metrics

Interim data suggest that previous DoD PDSS estimates were low and that significant amounts of software production are moving to 25 countries around the globe.

Initiatives are needed to consider the necessity of federal legislation and partnerships between government and industry to keep the U.S. leadership position in global software production. Consideration should be given to ways to improve coordination among key agencies (for example, the DoD, Department of Education, National Science Foundation, Office of Personnel Management, etc.) and industry to plan and implement appropriate actions to address the supply problem and the risk of losing the software industry to foreign competition. An interim briefing summary is available from capacity study staff.

In conjunction with the Software Process Program, Empirical Methods staff designed the process maturity questionnaire prototype, which was presented at the 1991 SEI Affiliates Symposium. Empirical Methods staff members will assist in the development and pilot testing of the updated questionnaire and related materials during 1992, leading to the release of updated products.

Project members assisted members of the Continuing Education Project and the U.S. Air Force Computer Resource Management Technology effort in developing a prototype of materials to use in conducting a training needs analysis. The set of questionnaires and guides is intended to collect data about the software work being done by people and the confidence levels those people have in doing the work their jobs require for analysis. These data provide one indicator of areas where training

may be needed. The questionnaires and related materials will undergo pilot testing in an Air Force operational command during 1992. The prototype will then be evaluated for broader development.

Empirical Methods staff supported the JLC and the DoD Software Action Plan (SWAP) in determining industry response to proposed changes in MIL-STD-881B and the creation of a WBS for software. A workshop of senior representatives from 14 major defense contractors was convened in August, 1991. The SEI facilitated the workshop, elicited candid comments, and prepared a report for use by the JLC and the SWAP.

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**Special Projects
Reports
1991**

National Software Capacity: Near-Term Study
(CMU/SEI-90-TR-12)

National Software Capacity: Near-Term Study Executive Summary
(CMU/SEI-90-SR-12)

For information on ordering copies of SEI reports, see page 41.

Software Risk Management

The goal of the Software Risk Management Focus Area is to improve the management of risks that arise in the development of software-intensive systems. In this context, *risk* refers to the uncertainty and impact associated with an event; *management* refers to the identification and resolution of the risk. Managing risk, therefore, entails identifying those things that can go wrong and assessing their likelihood and impact. A premise of the Risk Focus Area is that confronting risk in a systematic way is fundamental to controlling the quality, cost, and schedule of software products.

The Risk Focus Area is exploring existing techniques and developing methods for managing risk, assessing practice, preparing organizations to manage risk, and conducting prototype risk assessment methods. To achieve its goal and objectives, the Risk Focus Area must not only provide the mechanisms for managing risks, but must also provide a process that can be implemented within a project and organization and that can facilitate the communication of risk issues. Communicating risk underlies the strategy of addressing risk throughout the acquisition process, with specific attention to developing risk-driven acquisition strategies and systematic risk reviews.

Individual projects have not been identified. However, two areas are supporting the Risk Focus Area objectives. The Technical Development Area provides the focus for developing the methods in risk management. The Operations Area provides the primary interface to the customers and conducts interviews and risk assessments as test vehicles for developing risk management methods. Activities in both areas are closely coupled and project members actively contribute across areas.

The Technical Development Area provides mechanisms, methods, and tools for risk management. Project members have developed a risk paradigm as an approach to risk management and are exploring both existing technology and new methods to identify, analyze, plan, track, control, and communicate risk to improve risk management within the defense community.

During 1991, the project continued the initial effort and developed three mechanisms to identify risks in programs: risk appraisal, taxonomy, and matrix.

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Technical Development

Risk Focus Area members also developed a questionnaire for the government (derived from the industry questionnaire) that will gather information on how DoD services handle risk management and risk communication. The questionnaire was used in the program's first government program office interview in May.

In October, staff members conducted a joint SEI National Security Industrial Association Conference where more than 20 papers were presented to approximately 125 attendees from government, industry, and academia. The conference addressed both theory and practice. To prepare for this conference, a workshop targeting the academic community was held in February.

Staff members prepared a report on observations made as a result of program interviews and risk assessments. The report was formally reviewed and is being prepared for publication.

A risk management module in the Continuing Education Project Executive Series course entitled, "Software: Profit Through Process Improvement," was developed and delivered.

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Operations

The Risk Focus Area is developing its methods through field work with government and industry defense programs. The Operations Area provides the development and conduct of interviews, risk assessments, risk assessment training, and risk profiles. Risk management methods are improved through active field work. This area will develop methods to facilitate and strengthen risk communication through a rational, visible structure for identifying and analyzing risk. This area is concerned with creating viable methods for communicating risks internally within projects and externally to higher levels of management.

In January, staff members held a government workshop for Program Executive Officers and senior-level executives from the services and the Office of the Secretary of Defense.

Staff members participated in developing the DoD Software Technology Strategy and developed a plan for addressing risk in the acquisition review process. Staff members also conducted two company interviews on four separate projects. Information was gathered during the interviews to assess practice and identify risks in defense related programs.

Members of the Risk Focus Area also successfully negotiated an agreement with their first strategic DoD partner, the Navy. In addition to presenting future plans to the program managers, staff members completed interviews of two government program offices.

At the 1991 SEI Affiliates Symposium, staff members conducted a Risk Taxonomy Workshop. The workshop focused on obtaining feedback about the risk taxonomy used during risk assessments.

Staff members also completed the first risk assessment, which included assessment team training, a quick look assessment, and a detailed analysis of two risk areas. In November, the program completed the training and quick look steps in its second risk assessment.

Software Engineering Education

The primary objective of the education group is to increase the number of highly qualified software engineers by rapidly improving software engineering education throughout the education communities of academia, government, and industry.

The Graduate Curriculum Project is developing model curricula, promoting the growth of software engineering programs in the academic community, and working to increase the amount of software engineering content in computer science programs, primarily at the graduate level. The project produces a variety of publications for educators, including a series of educational materials.

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Graduate Curriculum

The project completed three new products related to software engineering project courses this year. *Models of Software Engineering Project Courses* (CMU/SEI-91-TR-10) uses data from the 1990 *Software Engineering Education Directory* (CMU/SEI-90-TR-4) and the authors' teaching experiences to assess the spectrum of software engineering project courses in the United States. Further details of how to teach such courses were captured in *A Software Engineering Project Course with a Real Client* (CMU/SEI-91-EM-4) and *Materials for Teaching a Project-Intensive Introduction to Software Engineering* (CMU/SEI-91-EM-6). Also released was an educational materials package, *Scenes of Software Inspections: Video Dramatizations for the Classroom* (CMU/SEI-91-EM-5), consisting of a videotape and a report describing how the tape can be used to teach the software inspection process.

Two releases this year were updates of earlier publications. The *1991 SEI Report on Graduate Software Engineering Education* (CMU/SEI-91-TR-2) includes a model curriculum, an annotated bibliography of software engineering textbooks, and descriptions of major software engineering research journals. The *Software Engineering Education Directory* (CMU/SEI-91-TR-9) summarizes information about software engineering courses and degree programs offered by universities, primarily those in the United States.

The 5th annual SEI Conference on Software Engineering Education was held in Pittsburgh, followed by a one-day Educator Development Workshop, at which many of the new products of the project were presented and discussed. As in previous years, the project also presented a series of tutorials on software engineering in connection with the annual Association for Computing Machinery, Special Interest Group on Computer Science Education (ACM SIGCSE) Technical Symposium, a major symposium for computer science educators.

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**Master of Software
Engineering**

In response to industry's growing demand for skilled software developers, CMU offers a 16-month master's degree program in software engineering. The program is a joint effort of the CMU School of Computer Science and the SEI. The core of the program is based on the SEI curriculum recommendations for Master of Software Engineering (MSE) programs. The MSE Project also produces the Academic Series, a set of videotaped graduate-level courses on software engineering.

The CMU MSE program graduated its first six students in December 1991. Three were full-time students who began the program in August 1990; the other three, including one SEI employee, completed the program through part-time study.

In the Software Development Studio, an ongoing project course, students completed a system that allows users to graphically manipulate database objects, and delivered the product and documentation to their customer in the CMU Department of Architecture.

The MSE program welcomed 21 students in 1991; 16 are attending full-time and 5 part-time. The students represent major computer companies such as Hewlett-Packard and Digital Equipment Corporation, as well as government, aerospace, and financial institutions. The studio projects for this class include joint work with the CMU and University of Karlsruhe Architecture departments, the CMU Philosophy Department, the CMU Robotics Institute, and three SEI projects (Distributed Systems, Real-Time Embedded Systems Testbed, and Rate Monotonic Analysis for Real-Time Systems).

The Academic Series completed its eighth semester of production in the spring by videotaping three courses: Software Creation and Maintenance (Version 2); Software Project Management (Version 2); and Software Analysis (an update of Software Verification and Validation). In the fall, Software Requirements Engineering was taped and used concurrently at two universities.

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Continuing Education

The Continuing Education Project interacts with industry and government to increase the availability of high-quality educational opportunities for software practitioners and executives. The project produces the Continuing Education Series and the Technology Series. The Continuing Education Series provides video-based courses designed for customers' in-house education, and executive offerings designed for decision makers involved in improvement efforts. The Technology Series provides stand-alone presentations that promote awareness of emerging issues and leading-edge technologies.

This year, the Continuing Education Project developed Software Quality Improvement, an executive seminar for the Continuing Education Series. The seminar was presented three times; and a seminar developed previously, "Software: Profit Through Process Improvement," was presented four times. A new addition to the executive curriculum, "Software Productivity Improvement," was prepared for release in spring 1992.

From the Continuing Education curriculum for practitioners, the project presented "Software Project Management" for Instructors twice and developed a new course for presentation in 1992: "Software Requirements Engineering."

A new videotape, *Executive Leadership for Software*, was added to the Technology Series. In this videotape, Watts Humphrey describes an improvement strategy based on the capability maturity model developed at the SEI.

As part of work defined by the Air Force Computer Resource Management Technology Program, project staff developed and piloted a prototype instrument called the Software Engineering Training Needs Analysis Survey. The instrument has been developed for organizations using DoD development standards.

Finally, the project hosted a workshop on August 26, the day before the Affiliates Symposium. The majority of the 53 attendees were from industry, though there were 9 participants from government organizations and 2 from universities.

The Undergraduate Curriculum Project, initiated mid-1991, focuses on the long-term development of a highly qualified work force by addressing the needs of the majority of undergraduate computing students who do not pursue an advanced degree. The project promotes and accelerates the development of software engineering as an academic discipline and promotes the establishment of undergraduate software engineering degree programs in the academic community.

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**Undergraduate
Curriculum**

At the SEI Affiliates Symposium, project staff presented a model undergraduate curriculum in a talk entitled "In Search of the Next Generation of Software Engineers." A similar presentation on the Bachelor of Science in Software Engineering was given at the Washington Ada Symposium and Summer SIGAda (ACM Special Interest Group for Ada) Meeting held in McLean, Virginia. Participants in the session were primarily from the defense contractor community. The project leader also presented issues of undergraduate software engineering education as part of the IBM/Florida Atlantic University Distinguished Lecture Series. The audience included many representatives of major software companies in south Florida.

The project published an annotated bibliography of software engineering textbooks in the June 1991 issue of the *SIGCSE Bulletin*, a publication of the ACM.

The project advised DARPA on ways to increase software engineering content in undergraduate computer science curricula and to encourage the teaching of Ada in undergraduate courses. As a result, DARPA recently announced a curriculum development grant program, funded jointly by DARPA and the Ada Joint Program Office. A project member helped DARPA review the proposals for grants.

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Software Engineering Education Reports

1991

1991 SEI Report on Graduate Software Engineering Education
(CMU/SEI-91-TR-2)

Software Engineering Education Directory
(CMU/SEI-91-TR-9)

Models of Software Engineering Project Courses
(CMU/SEI-91-TR-10)

A Software Engineering Project Course with a Real Client
(CMU/SEI-91-EM-4)

Scenes of Software Inspections: Video Dramatizations for the Classroom
(CMU/SEI-91-EM-5)

Materials for Teaching a Project-Intensive Introduction to Software Engineering
(CMU/SEI-91-EM-6)

For information on ordering copies of SEI reports, see page 41.

DARPA/STARS

As Ada use becomes more common in software-dependent systems and as requirements grow, system developers will be faced with both the benefits and problems of adopting more disciplined and integrated approaches to software engineering. The goals of DARPA/STARS Support are: to help remove technical and managerial obstacles which can prevent Ada from being adopted; to support the STARS Program in technology development, integration, and transition efforts; and to support DARPA efforts to develop, evaluate, and disseminate new software engineering approaches derived from the development of software architectures characteristic of particular application areas.

The Binding of Ada and Structured Query Language (SQL) Project, initiated at the request of the Ada Joint Program Office, has investigated the problem of binding the Ada programming language with the SQL database language. The solution to this problem was the specification of the SQL Ada Module Extension (*SAME), an architecture for Ada SQL applications that emphasizes software engineering principles.

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**Binding of Ada
and SQL**

The SQL Ada Module Description Language (SAMEDL) allows for the partial automation of Ada SQL programs having the SAME architecture. The SAMeDL is under commercial development. It has been specified in the Army Tactical Command and Control System (ATCCS) and it is in the process of being standardized by the International Standards Organization.

The report *Rationale for SQL Ada Module Description Language SAMeDL* (CMU/SEI-91-TR-4) was published this year. This report explains the design principles behind the SAMeDL and explains how the language is intended to be used.

Another report, *Notes on Applications of the SQL Ada Module Description Language (SAMEDL)* (CMU/SEI-91-TR-12) was also published this year. This report explains how the SAMeDL can be adapted and extended to provide services to applications needing advanced features, using non-ANSI standard data types, or having other unusual requirements.

STARS/Users Workshop: Final Report—Issues for Discussion Groups
(CMU/SEI-90-TR-32)

Rationale for SQL Ada Module Language Description (SAMEDL)
(CMU/SEI-91-TR-4)

Notes on Applications of the SQL Ada Module Description Language (SAMEDL)
(CMU/SEI-91-TR-12)

For information on ordering copies of SEI reports, see page 41.

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**DARPA/STARS
Reports**

1991

CERT Coordination Center

The Computer Emergency Response Team Coordination Center (CERT/CC) supplements existing mechanisms that informally organized experts use to deal with and prevent computer emergencies. The CERT/CC at the SEI supports two different communities: Internet users and the developers of technology that is available on the network, such as UNIX and networking software. The CERT/CC provides a dependable, 24-hour point of contact for security issues and allows rapid communication during emergencies. It also raises constituents' awareness of security issues and assists individual organizations in improving the security of their systems. Finally, the CERT/CC maintains a highly secure repository of information for team members and cultivates close ties with researchers in the area of trusted systems to improve the security of existing systems.

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Since its inception in 1988, the CERT/CC has responded to a continuous stream of reported security incidents. These include reports of intrusions, worms, and viruses as well as reports of vulnerabilities and suggested fixes for problems. In handling these problems, the CERT/CC issues advisories to the Internet community to warn them of problems and inform them of preventive techniques. In cases where vulnerabilities exist, the CERT/CC works with software vendors and the technical community in analyzing and resolving the problems.

The third annual Computer Security Incident Response Workshop was held in Washington, DC, on August 6-8, 1991. Papers, invited presentations, and workshops covered the following topics: network intrusions, incident handling procedures and policies, legal and investigative issues, system vendor activities, ethical issues, vulnerabilities and malicious code, securing wide area networks, and Forum of Incident Response and Security Teams (FIRST) system operations.

The CERT/CC completed a tutorial on securing Internet systems. The tutorial was first presented at the third annual Computer Security Incident Response Workshop.

The CERT/CC continued working with the Internet Engineering Task Force (IETF) to produce guidelines for the secure operation of the Internet. The Internet Engineering Steering Group has recommended that the guidelines be approved as a final Informational RFC (request for comments). (Final Informational RFCs have been reviewed and approved, and are not open for further comment or discussion.)

Team members participated in the IETF Site Security Policy Handbook Working Group, which has produced a security handbook for Internet-connected site and system administrators. The handbook outlines key issues and provides guidance on

policy, administrative, and technical issues to support administrators' efforts at improving the security of their systems. Final editing of the handbook has been completed, and it is available from the IETF as RFC 1244.

The CERT/CC staff beta tested Trusted Information Systems' Privacy Enhanced Mail as part of a larger effort to evaluate the package and feasibility of use on a wide scale. The package uses private and public key encryption techniques to authenticate mail senders and to protect the privacy of the transmitted message.

The CERT/CC continued to take a lead position in the development of the FIRST System, a federation of organizations working together to improve the security of their systems. FIRST System charter members, 11 federally funded groups, have formed a steering committee chaired by a member of the National Institute of Standards and Technology, and elected a Secretariat. They have also formed three working groups focused on: inter-CERT communications mechanisms, information content and format standards, and workshop and conference agendas. FIRST System workshops were held in March and November 1991. Topics discussed were details of backup communication mechanisms, advisory content and format, and future workshops.

An archive service for clippings related to computer security was created. This archive is a central repository for selected security-related Usenet News and mailing list postings. The clippings archive is available via anonymous ftp from the cert.sei.cmu.edu (192.88.209.5) system in the directory pub/clippings.

The CERT/CC is participating in the IETF Common Authentication Technology Working Group. This group is involved in creating a generic interface that can be used by a number of protocols (for example, telnet) to provide authentication.

The CERT/CC participated in a meeting of the Trusted Systems Interoperability Group (TSIG). The TSIG is a group of approximately 70 members, most of whom are vendors trying to introduce security standards into the IETF mechanisms.

During the fourth quarter, DARPA approved the expansion of the CERT/CC. In 1992 the CERT/CC will include more resources dedicated to education and training, and initial research efforts to develop tools and techniques to test and enhance security in existing systems.

Affiliate Relations

The Affiliate Relations Function establishes and maintains SEI relationships with industry, government, and academia, providing access to SEI information through mailings, telephone contact, special meetings, and symposia. Affiliate Relations also cooperates with the SEI Joint Program Office to negotiate for and place resident affiliates at the SEI.

In 1991, 14 new educational organizations became affiliates and 36 new industry organizations signed affiliation agreements for information exchange and information dissemination. In addition, 19 organizations sponsored resident affiliates at the SEI. The following organizations sponsored resident affiliates during 1991:

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Air Force

Electronic Systems Division
Standard Systems Center

Army

Communications and Electronics Command

Navy

Naval Coastal Systems Center
Naval Ocean Systems Center

Other Government

Defense Logistics Agency
National Security Agency

Industry

AT&T Bell Laboratories
Boeing
Computer Sciences Corporation
GE Aerospace
GTE

Hughes Aircraft Company
IBM
Texas Instruments
Unisys
Telesoft

Academia

Universidad de Cantabria

The sixth annual SEI Affiliates Symposium was held in September in Pittsburgh. The symposium is a key forum for exchanging information among software professionals from industry, government, and academia. The symposium included more than 25 hours of presentation material that highlighted SEI programs, plans, and activities. During this symposium, the SEI emphasized work in software process, featuring developments in the capability maturity model, the maturity questionnaire, and software measurement. More than 700 representatives from affiliate organizations attended the symposium.

For More Information

SEI publications are available for purchase. For additional information, contact:

Research Access Inc.
3400 Forbes Avenue, Suite 302
Pittsburgh, PA 15213
Telephone: 1 800 685-6510
FAX: (412) 682-6530

or

**NTIS: National Technical Information Service
U.S. Department of Commerce
Springfield, VA 22161-2103
Telephone: (703) 487-4600**

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How to Order SEI Publications

To be added to the Bridge mailing list, write to:

**Software Engineering Institute
ATTN: Bridge Mailing List
Carnegie Mellon University
Pittsburgh, PA 15213-3890
Internet: bridge-editor@sei.cmu.edu**

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How to Get the SEI Magazine

For information on access to SEI public offerings, contact:

Software Engineering Institute
ATTN: Customer Relations
Carnegie Mellon University
Pittsburgh, PA 15213-3890
(412) 268-6815
Internet: customer-relations@sei.cmu.edu

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How to Become an SEI Affiliate

For general information about the SEI, contact:

George Heidekat
Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-3890
(412) 268-6257
Internet: grh@sei.cmu.edu

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How to Get Additional Information

List of Acronyms

AAS	Advanced Automation System
ACEC	Ada Compiler Evaluation Capability
ACM	Association for Computing Machinery
AES	Ada Evaluation System
AESOP	Assistant for Evaluation of Software Practices
AFB	Air Force Base
AFECO	Air Force Electronic Combat Office
AFSC	Air Force Systems Command
AMC	Army Materiel Command
ARTEWG	Ada Runtime Environment Working Group
ASD/YT	Aeronautical Systems Division, Deputy for Simulators
ATTCs	Army Combined Arms Support Command
AWG	Architecture Working Group
BOT	Basic Operator Trainer
CARDS	Central Archive for Reusable Defense Software
CASCOM	Combined Arms Support Command
CASE	Computer-Aided Software Engineering
CECOM	Communications and Electronic Command
CERT/CC	Computer Emergency Response Team Coordination Center
CIM	Computer integrated manufacturing
CM	Configuration management
CMM	Capability Maturity Model
CP	Ceiling Protocol
CSCI	Computer software configuration item
CSE	Control Systems Engineering
CSITE	Combat System Integrated Training Equipment
DAMMS-R	Army Movement Managements System—Redesign
DARPA	Defense Advanced Research Projects Agency
DMSO	Defense Modeling and Simulation Office
DOD	Department of Defense
DS	Distributed Systems
ECMA	European Computer Manufacturer's Association
ESD	Electronic Systems Division
FAA	Federal Aviation Administration
FFRDC	Federally funded research and development center
FODA	Feature-Oriented Domain Analysis
FSD	Federal Systems Division
FTM	Fault Tolerant Mach
IDA	Institute for Defense Analyses
IEEE	Institute of Electrical and Electronic Engineers, Inc
IETF	Internet Engineering Task Force
INS	Inertial navigation system
IOCPP	I/O Controller / Post Processor
ISEC	Information Systems Engineering Command
ISEE	Integrated software engineering environment
JLC	Joint Logistics Commanders
J-MASS	Joint Modeling And Simulation System
JPIL	Jet Propulsion Laboratory
LAN	Local area network
MCC	Microelectronics & Computer Technology Corporation
MCCR	Mission-critical computer resource
MCNC	Microelectronics Center of North Carolina
MSE	Master of Software Engineering
NADC	Naval Air Development Center

NASA	National Aeronautics and Space Administration
NCSC	Naval Coastal Systems Center
NGCR	Next Generation Computer Resource
NIST	National Institute of Standards and Technology
OCU	Object-Connection Update
ONR	Office of Naval Research
PCP	Priority Ceiling Protocol
PDAG	Process Definition Advisory Group
PDR	Preliminary design review
PDSS	Post-deployment software support
PIWG	Performance Issues Working Group
PN	Periodic non-harmonic
PSESWG	Project Support Environment Standards Working Group
REST	Real-Time Embedded Systems Testbed
RFC	Request for Comments
RMA	Rate Monotonic Analysis
RMARTS	Rate Monotonic Analysis for Real-Time Systems
RTCN	Real-time computing network
SAE	Software Architectures Engineering
SAEM	Software Acquisition Evaluation Methods
SAMeDL	SQL Ada Module Description Language
SATWG	Strategic Avionics Technologies Working Group
SCE	Software Capability Evaluation
SCM	Software configuration management
SCM3	Software Configuration Management
SDE	Software Development Environments
SEI	Software Engineering Institute
SEPG	Software Engineering Process Group
SIGAda	Special Interest Group for Ada
SIGCSE	Special Interest Group on Computer Science Education
SOF ATS	Special Operations Forces Aircrew Training System
SPA	Software Process Assessment
SQL	Structured Query Language
SSC	Standard Systems Center
STARS	Software Technology for Adaptable, Reliable Systems
SWAP	Software action plan
SWTS	Software Technology Strategy
TO&P	Technical Objectives and Plans
TSIG	Trusted Systems Interoperability Group
WBS	Work breakdown structure
WBS.SW	Work breakdown structure for software
ZDAK	Zero-Defect Application Kernel